Computer Applications in Health Services

A Socio-Economic Report of the Bureau of Research and Planning, California Medical Association

TWENTY-FIVE YEARS AGO, the computer had scarcely been dreamed of; today it is practically impossible for an urban American to pass a day without at least indirect contact with one. The role of the computer in recording the events of our lives, from birth to death, is already of primary importance. Among their other functions, computers are used in figuring income taxes, credit card use, consumption of materials, and for statistical analyses such as computing the cost of living index. This primary role of the computer, recording, has been extended into the entire health care industry, where it holds considerable promise. This *Socio-Economic Report,* in addition to bringing together information on recent computer advances in medicine, will elaborate on some current and future possibilities for computer applications in the health fields.

Before discussing these applications, however, a brief review of the functions and capabilities of the computer in general is in order. These basic functions are: (1) Data Input: The ability to translate data, from instruments or man, into computer language. (2) Data Processing: The manipulation of data to answer inquiries. (3) Information Output: The ability to provide processed data in usable form. (4) Communication and Transmission: The ability to transmit data from input-source to computer to output, regardless of location. (5) Reliability, with emphasis on speed and convenience of the system.[1] The potential applicability of such a system to a field where the amount of scientific knowledge has approximately doubled *each decade* since 1900, is the subject of this *Report.*

It should be emphasized that references to specific systems in this *Report* do not imply their endorsement.

Currently, a major problem in the health care field is the lack of availability of medical services. To label this lack "the doctor shortage" is an over-simplification. A shortage of services usually provided by the physician does exist, but not all of these services necessarily require the skills of a physician. In the private practice setting, for example, many of the functions of the computer such as accounting and bookkeeping, which could serve to free the physician from time-consuming tasks, have been restricted by the high cost of such services. However, as these financial limitations are removed, and as the cost of labor rises, the need for better ways to meet increased demands on the patient care system can take precedence.[2]

Since traditional methods of data gathering and dispersal are becoming increasingly cumbersome, the expansion of the base of medical information must be viewed with computer support in mind. According to officials of IBM's Advanced Systems Development Division at Yorktown Heights, New York, the focus of research over the next ten years will be to: (1) use the computer to expedite the "total flow of information" going on within the hospital; and (2) expand the application of computers as therapeutic and diagnostic aids.[3]

While medical computer usage in the 1960's was largely concerned with superior record keep-

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ing and billing procedures, and with applications in research and education, the emphasis is currently changing to include more critical medical tasks. There is no question, experts maintain, that the computer is now relevant to four major concerns of medicine: office operations, patient care, medical research, and diagnosis and treatment planning. Insofar as these areas are separable, they will be individually discussed.

Office Operation

Systemedics, one of various medical office systems available to physicians, provides a wide variety of office services. This system prepares each physician's statements or credit letters, detailing every charge or receipt; identifies the patient if more than one dependent visited the practice during the month; and, in the case of group practice, lists the physician who performed the treatment. Systemedics can segregate private insurance or Medicare charges and store them until treatment is completed, then retrieve the charges along with other pertinent stored claim data. A complete history with detailed charges is sent to the physician on a physician's service report which is acceptable to the majority of insurance carriers. Each month, a complete alphabetical listing of active accounts is provided showing billing charges, delinquency status, insurance activity, payment history, and the allowable figure for income tax deductions for each account.

The physician selects the period an account is to remain open; after that, a series of credit letters is sent automatically. The computer ages every account and tracks each delinquency. Also, each month the physician's accounts receivable are totalled, showing charges, receipts, amounts delinquent, growth development of the physician's practice, and other data pertinent to the management of the office. For partnership practices, each physician's production can be accurately totalled.

In an effort to speed and control the payment of medical bills for physicians, a unique new computerized system has been designed and developed by Blue Cross and Blue Shield of Virginia and Western Data Products of Los Angeles. This new system will allow a doctor to transmit a claim for service to Blue Cross and Blue Shield by means of a keyboard type terminal device in his own office. The data will be transmitted into a data center; verification of the claim will be returned to the physician within seconds through an automated voice response. The claim will then be processed and a check issued. It is asserted that the advanced system will substantially reduce paper-work and administrative costs in the doctor's office, as well as prevent errors in the payment of claims.[4]

Patient Care

During the initial phase of medical computing, many programs were set up to automate physicians' orders, laboratory reports, and other similar functions. These "first generation" systems provided clinical medicine with much needed experience in this new field, but for the most part these programs were not addressed to the task of uniting medicine with the new technology. The "second generation" programs, written during the past three or four years, have focused on clinical rather than clerical problems, and have brought computer usage into medical judgment and therapeutic decisions. Essentially, these programs attempt to establish organized data banks of one sort or another with clerical benefits a matter of secondary importance.

Second generation programs will necessitate the development of a full clinical system. When data from many patients are stored in a computer memory bank, imaginative organization of input, storage, and output is necessary for useful retrieval. To insure comparability of similar cases, rigid uniformity in the recording of data is imperative. Therefore, the first step toward establishing a useful data bank is the standardized input of all medical records. This standardization has been achieved by designing a set of prestructured records which can closely follow the working habits of the physician. Of course, these records must be computer-compatible.

It is important to keep in mind that the present commercially available computers are fully adequate for the operation of this type of data bank. Even the cost is not excessive when compared with inefficient manual methods. The present difficulty lies mainly in designing the full system, the medical input structure, and in training physicians to adjust to the system's technology.[5]

A computer system can provide the tools for more logical and efficient management of all aspects of information in the preservation of pa-

tient health and in the treatment of illness. The Yale Medical Computer Science Section, for example, is applying computers to the management of information in patient care. In developing automated systems for the collection and retrieval of medical histories, the Yale group is departing in emphasis from other systems by using computers and information science in research and teaching relevant to changing patient care needs. Medical decisions are simplified for the practitioner, for paramedical personnel, or for the computer if the right data are assembled in an orderly and logical fashion. A computer-aided medical history data bank will vastly improve the present diversified ways of assembling medical information. But the goal of more efficient medical information recording and retrieval will be worthwhile only if physician effort is spared by automation and increased use of paramedical personnel.[6]

Most experts believe that the hospital will probably remain the major point of contact between doctors and computers. The goal of current planning is a hospital information system capable of giving an instant report, containing every useful item of information about any given patient. The need for such a system is overwhelming, if only to keep track of all the data produced in a hospital. It has been estimated (by Melville H. Hodge, Assistant Director of Information Systems for Lockheed Missile and Space Corporation) that as much as 30 percent of all hospital costs go for manual information handling. And processing of a single laboratory test order may involve twelve written information transfers. For example, Boston's 1,000-bed Massachusetts General Hospital admits 30,000 patients annually, treats another 50,000 in its emergency rooms, and handles 125,000 outpatient visits. Every admission results in a flood of information to be sent to 66 different areas. The hospital's 24 laboratories perform one million procedures a year. Every day 4,000 calls are made for records; one in five of these records cannot be immediately located.[7]

The State University of New York's Downstate Medical Center in Brooklyn appears to have developed the most advanced hospital information system in use today. This computer has 49 teletypewriter stations, with nine more located at other hospitals in Brooklyn to form an emergency-bed-assignment system. Almost every bed in Downstate's hospital is assigned by the computer. In assigning a bed to each entering patient, the computer is programmed to consider age, medical condition, and sex, among other factors.

The computer also handles laboratory, x-ray, drug, and other orders of a similar nature. The physician enters the request on the patient's chart in the usual way. An assistant then types out the order at the nearest computer terminal. In the case of a lab test, the technician who performs the test transmits the results back through the computer, which stores the data and bills the patient automatically.[7]

High cost will probably prevent all but the very largest hospitals from having their own computer systems. Therefore, Lockheed at Sunnyvale, California, recently proposed a Medical Information System which will link several hospitals to a centrally located electronic data processing system. The proposed system would have video screens placed at various points throughout a hospital. Access to the computer would be made through the video screen by means of a "light pen," which is used to write orders directly on the screen.

The proposed system would encompass doctors' orders, medications, pharmacy orders, nurses' instructions, periodic shift reports, and 24-hour summaries for each patient, making instantly available to the physician a complete status report on each patient. This system is specific enough for the needs of the physician, a quality lacking in other medical information systems.

The regional availability of the proposed system can produce substantial savings to hospitals, since each would not have to buy or lease its own high-priced computer hardware. Lockheed has designed a system which is extremely efficient and workable as presented. The major problem encountered in implementing the system would be in training medical personnel in the use of the computer and in orienting them toward electronic technology.

Medical Research

The computer is an extremely powerful and versatile tool, adaptable to a wide range of tasks involving data acquisition, editing, and storage; information retrieval and display; complex mathematical computation and data reduction; and

information feedback and control. Therefore, the compter has great actual and potential applicability to research in medicine and, through progress in research, to increased quality of medical care.

Despite the computer's obvious potential, many biomedical scientists have for a number of reasons been reluctant to use electronic data processing. High costs have limited the amount of automatic data processing equipment available to the biomedical researcher. Also, there has been little variation in the types of equipment available; the new, small, highly flexible computers essential to clinical and laboratory research are of relatively recent design.

Further, the computer is essentially a mathematical machine, with the primary capability of rapid and accurate evaluation of numerics. Unfortunately, medical researchers may be relatively unsophisticated in mathematics. However, the boundaries which have separated computer science from medical technology can be broken down through programming and input-output devices so as to provide the medical researcher with a tool with which he can work comfortably and freely. Although the medical researcher cannot be expected to have a high level of knowledge in computer science as well as in his own specialty, he must develop the ability to program his problems in a manner suitable to the computer technology provided by his computer scientist colleagues.[8]

Medicine is now on the threshold of realizing the potential of the computer. The transition of medicine from a descriptive to an analytic science is accelerating; there is more financial support for new equipment, and mathematical and computer science competence is expanding into the biomedical work of physical scientists and engineers. Such specialties as bio-electronics, bio-medical engineering, physical biology, neurochemistry, and bio-mathematics, as well as biochemistry, are breaking down the traditional lines dividing professional specialties. The most pressing task now is the adaptation and expansion of computer technology to fit the changing requirements of medical research.[9]

In this area, a computer which helps clinicians to determine the difference between normal and cancerous cells has been developed at the University of Chicago. Known as TICAS (Taxonomic Intracellular Analytic System), it makes finite distinctions between cells that otherwise could not be detected. As the microspectrophotometer scans cells, diagnostic information is transmitted automatically to the computer. This system has been programmed with information from expert cytopathologists from all over the world. Remembering every cell it scans, the computer can identify unknown cells to determine if they are cancerous. TICAS will soon be detecting premalignant and early malignant conditions for clinics. In this way it will help to establish reproducible cytopathologic standards, help control the quality of tissue cultures, and assess the threshold effects on cells of drugs, viruses, and radiation.[10]

Consulting the literature instead of the consultants is another job that a well-programmed computer handles with ease. The National Library of Medicine has for some time been using a computer system called MEDLARS (Medical Literature Analysis and Retrieval System) to keep track of hundreds of thousands of medical articles. This system is now cross-indexing some 250,000 articles each year, and, according to Doctor Richard M. Magraw,[11] may someday largely supersede the *Index Medicus*. Since computers can examine data faster and more accurately than men can, the doctor's request for a bibliography on a given subject can be answered promptly by a computer retrieval system, saving hours or even days of search time.[11]

Diagnosis and Treatment Planning

The necessity for computer aid in medical diagnosis and treatment planning is more apparent each day. Such methods will be required to make multiphasic screening a practical and feasible procedure; even the use of computers in the physician's office by means of telephone or remote console may become a practical necessity in the future. Already, computer methods are being introduced into outpatient clinics to assist with their ever-increasing load. But before such use of computers becomes widespread, many outstanding problems must be solved. First, the process of evaluating the patient's symptoms, whether by clinical examination or by laboratory test, must become more accurate. Much has been written on the subject of diagnostic error, most of which results from errors in symptom evaluation. Second, computer methods, including relevant mathematical analysis,

must be further improved to take into account the practical problems that have been discovered to date. And, finally, the collection of data must be systematically automated so that such things as input numbers, probabilities, and values can be conveniently collected and transmitted to the proper users in the correct form.[12]

When the problems discussed above are solved, the computer will be able to: (1) produce a list of possible diagnoses consistent with the medical knowledge for a given set of symptoms presented by the patient; (2) indicate further diagnostic tests which best differentiate among remaining diagnostic possibilities; (3) calculate the probabilities for alternative diagnostic possibilities; (4) enable a more precise statement and analysis of the value decisions which may be associated with treatment planning; (5) compile statistics which relate symptom-disease combinations and which evaluate disease-treatment prognosis results; (6) make feasible the utilization of more quantitive criteria that has heretofore been possible in the evaluation of the results of certain diagnostic procedures (such as electrocardiograms and electroencephalograms), as well as perform the complicated calculations necessary for the proper interpretation of many other clinical measurements; (7) significantly aid medical-information retrieval (for example, the computer is able to rapidly retrieve current information about new preventive measures, diagnostic techniques, and specific treatments). Finally, the computer is able to: (8) easily accumulate and recall desired aspects of a particular patient's total medical record, such as total radiation dose received, previous allergic reactions, and individual biochemical and physiologic norms and deviations.[13]

The first in a series of automated multiphasic screening and testing systems has been installed in Cherry Hill, New Jersey to perform health appraisals as a service to individual physicians, industries, unions, and government organizations. This system features the use of computer techniques to permit direct interaction of the patient testing station with a high-speed data processor. Patients move through a complete battery of tests and measurements which results in a detailed health profile. No diagnosis is accomplished as a part of the process. Rather, the results of the various tests are printed in a form convenient for physician analysis. A wide battery of diagnostic tests are provided, including medical history, blood analysis, urinalysis, cytology, anthropometry, spirometry, chest x-ray, visual acuity audio acuity, tonometry, electrocardiogram, blood pressure, and other cardiovascular measurements. In addition, plans are under way to utilize advanced techniques for the early detection of cancer of the breast. This program is the first application of the new Searle Medidata system to large scale health screening by private industry, and is similar to one in operation at the Alta Bates Community Hospital in Berkeley, California.[14]

The model for all other currently functioning multiphasic screening clinics is the one conducted by the Kaiser Foundation Health Plan, Inc., in Oakland and San Francisco, California. On the basis of the experience of the Kaiser-Permanente program, automation of the laboratory aspects of the periodic health examination has proven to be successful. Some of the major advantages in the multitest laboratories are that the patient receives a large battery of tests in an efficient and inexpensive manner, and the physician is supplied with comprehensive, quality information which conserves his time and aids him in the management of the patient. When an average of 500 persons are tested per week, the total per person cost of such testing has been calculated at $21.32. Of this, the cost of the data processing aspects is $4.50. In addition to recording results of individual tests, the computer is programmed to call for such additional testing as may be considered medically advisable and to arrange for follow-up appointments with a physician.[15]

Problems in Computer Application

Aside from the technical problems, such as programming, some of the major barriers encountered in adapting computer usage to the health care field should be discussed. Perhaps the most far-reaching of these problems is the education of the personnel involved. Ease of utilization is of primary importance at every level, from the physician to the nurses' aide; and this necessary familiarity can come only through education in computer usage. Although full discussion of this subject is not within the scope of this *Report,* it should be noted that unless the physician, nurse, or hospital administrator knows how to utilize it properly and fully, the

largest computer in the world would be nothing more than an expensive nuisance.

Thus enters the second barrier to widespread immediate automation: cost. These two factors, cost and education, are inextricably linked in the following fashion: a large proportion of the hospitals in the United States today could afford the services of a computer, at least on a time-sharing basis. (Under the time-sharing system, one or more rented teletypewriters are linked to a central computer, which can handle a large number of incoming calls simultaneously.) However, there is no such thing as half-way automation of, for example, admissions data or medication orders. And the process of training all the physicians who use the hospital, plus three shifts of nurses, bookkeepers, ward secretaries, and all the other personnel involved, in the fundamentally simple (from the user's point of view) techniques of computer usage, is prohibitively costly and time-consuming. Since there is no point, and some definite disadvantages, in installing a system that cannot be used efficiently, there must be a gap of at least one educational generation before computer installation in most hospitals can be considered feasible.

A third problem, noted above, is that the engineer, electronics expert, or computer specialist does not have the same viewpoint about problems of medical care as does the physician. Devices and aids, including some types of computer application such as monitoring devices, that would be ideal in theory, often must be modified drastically to be acceptable in practice to the physician and his patient. More is involved here than the usual difficulties encountered in the practical application of "pure" research, since the researcher is often in another field entirely, with little grasp of the physician's or the patient's needs; hence, the emergence of such specialties as biomedical engineering and electronics.

A fourth, and final problem is that many practicing physicians fear that the intrusion of electronic devices, particularly the use of computers in such areas as screening examinations and diagnostics, will interfere with the traditional doctor-patient relationship. In considering this problem, two points must be kept in mind; the computer is essentially a calculating machine, capable of providing extremely fast comparisons and statistics for huge sets of data and possessed of an enormous and, for practical purposes, infallible memory; and second, the computer is capable of neither judgment nor decision on its own, and can work only with the methods which have been supplied by the programmer and the data provided by the user.

Thus, the whole system is designed not to supplant the physician or to usurp his right of judgment, but to allow him quick access to the latest medical knowledge and opinion on the subject in which he is interested. Ideally, in fact, the computer will be able to relieve the physician of some of his more mechanical tasks and will provide an efficient means of keeping up to date on the areas of medicine most important to him. Indeed, unless expanding population and acute manpower shortages dictate otherwise, the physician is likely to find that he has more time to devote to his patients as individuals, and to gather more information of the type that cannot be handled by the computer—that part of the diagnosis which is based on subtle and personal cues.

There are many ways in which computers may significantly aid the physician. However, it should not be implied that computers will make the physician's job easier. On the contrary, he must learn to communicate with the computer and how to evaluate correctly the information obtained from it. Once physicians and other medical personnel have done this, however, the increased ability to make a precise diagnosis and to choose the optimum possible treatment plan will more than offset the difficulties involved in such utilization of the computer.

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